Building a Bridge to the Corn Ethanol Industry

Corn Stover to Ethanol Co-located at High Plains Corporation's York, Nebraska Site

Presented to the National Renewable Energy Laboratory
by Merrick and Company February 4, 2000

Opening

- Partners
  - High Plains Corp. – Existing corn to ethanol facility
  - PureVision Technologies Inc. – Cellulase production technology
  - Merrick and Company – Engineering and project management
- Scope – Explore the business potential of producing fuel ethanol from corn stover.

Opening (cont.)

- Background
- Technical Facility Features
- Facility Performance
- Financial Results
- Recommendations for Further Study

Background

- Co-located site
  - 37.5 million gal/yr fuel ethanol from corn and milo
  - Dry mill process
  - Industrial grade ethanol production capabilities
  - Sufficient stover available for a 900 dry metric ton/day corn stover to ethanol facility

Background (cont.)

- NREL Lignocellulosic Model
  - 2000 dry metric ton/day yellow poplar sawdust to ethanol
  - Technical memorandum for corn stover
  - On-site cellulase production
  - Simultaneous saccharification and co-fermentation

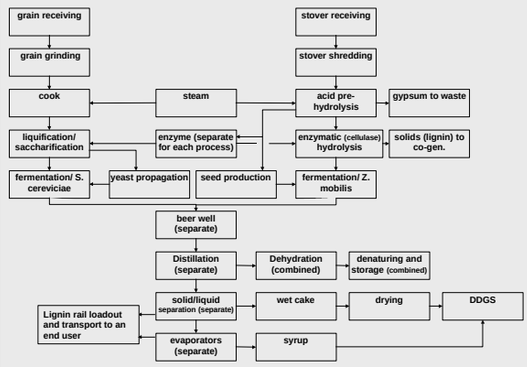
Background (cont.)

- Separation of Hydrolysis and Fermentation
- PureVision Cellulase Production Technology

Facility Features

- Block Flow Diagram
- Feedstock Handling
- Pretreatment
- Detoxification
- Cellulase Production
- Hydrolysis
- Fermentation Seed Production
- Co-fermentation
- Product Refinement
- Utilities
- Extent of Co-location Benefits

Block Flow Diagram



Facility Features

- Block Flow Diagram
- Feedstock Handling
- Pretreatment
- Detoxification
- Cellulase Production
- Hydrolysis
- Fermentation Seed Production
- Co-fermentation
- Product Refinement
- Utilities
- Extent of Co-location Benefits

Summary of Fermentation Results

High Plains York Co-located Summary:	York Co-located	% of reference model	NREL Lignocellulosic "Reference Model"
DTPD (metric ton)	900	100%	900
stover (dry short ton/yr)	347,223	100%	347,223
ethanol (gal/yr) after rectification	25,746,124	97.7%	26,340,609
yield (gal/dry short ton)	74.1	97.7%	75.9
yield (gal/dry metric ton)	81.8	97.7%	83.6
hydrolysis + ferm. Time (hr)	72.0	42.9%	168
conversion of cellulose to glucose	84.0%	95.5%	88.0%
Additional EtOH (gal/yr)	(594,485)		

Facility Features

- Block Flow Diagram
- Feedstock Handling
- Pretreatment
- Detoxification
- Cellulase Production
- Hydrolysis
- Fermentation Seed Production
- Co-fermentation
- Product Refinement
- Utilities
- Extent of Co-location Benefits

Co-location Benefits

- Land
- Administration
- Marketing
- Roads and Rail
- Operator Experience
- Ethanol Storage and Load out

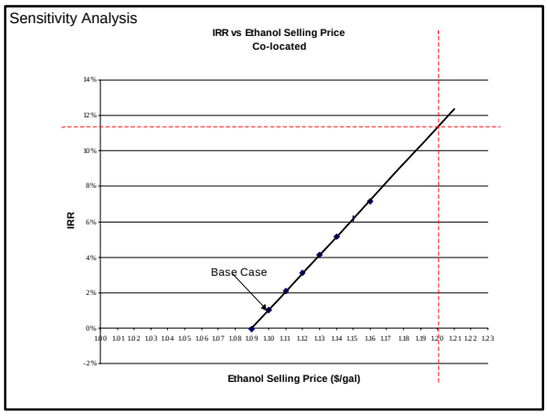
Facility Performance

- 900 dry metric tons per day
  (555.5 million metric tons/yr)
- 25.7 million gallons of EtOH/yr
- Yield of 74.1 gallons/dry short ton
  (81.7 gallons/dry metric ton)

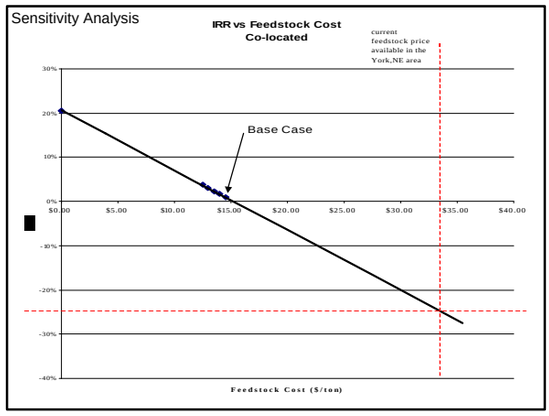
Financial Results

- Facility Cost: $85,884,262
- $/gal capacity: $3.34
- Capital Cost (equipment) $61,054,640
  As opposed to $75,875,432 for reference model
- IRR
  - ~ -25% for $35/dry short ton stover
  - 1% for base case (stover at $14.45/dry short ton)

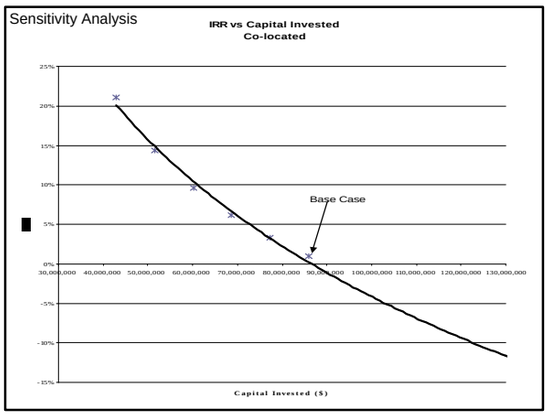
Sensitivity Analysis



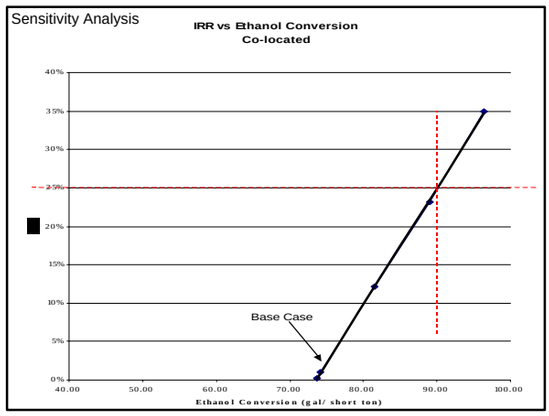
Sensitivity Analysis



Sensitivity Analysis



Sensitivity Analysis



Cellulase Source Study

	NREL* M FPU requiredlyr**	difference	Pure Vision M FPU requiredlyr
	1,446,984	(50,708)	1,497,692
Operating Projection:			
gal of fuel grade ethanol produced	$ 25,434,849	$ (311,275)	$ 25,746,124
Contract sale price per gallon	$ 1	$ -	$ 1
Gross Annual Revenue	$ 27,978,334	$ (342,402)	$ 28,320,736
Small Ethanol Producer Tax Credit			
@ $ - per gallon	$ -		$ -
Total projected ethanol sales and credit	$ 27,978,334	$ (342,402)	$ 28,320,736
Gross Annual Co-Product Revenue	$ 328,822	$ -	$ 328,822
Gross Sales and Credit	$ 28,307,156	$ (342,402)	$ 28,649,558
Operating Expenses:			
Utilities	$ 4,792,171	$ 567,400	$ 4,224,771
Raw Materials	$ 12,843,241	$ 96,523	$ 12,746,718
Processing Materials	$ 267,948	$ 66,987	$ 200,961
Operation & Maintenance	$ 6,414,114	$ 70,428	$ 6,343,686
Property Tax @ 0.50% Book Value	$ 486,736	$ 57,315	$ 429,421
Depreciation	$ 6,038,644	$ 744,902	$ 5,293,743
Total Operating Expense	$ 30,842,855	$ 1,603,554	$ 29,239,301
Net Operating Income	$ (2,535,699)	$ (1,945,956)	$ (589,742)
Net Operating Cash Flow	$ 3,502,945	$ (1,201,055)	$ 4,704,000
enzyme cost (cost of production calculated in "$per lb. calcs.") divided by lbs. per year flow rate from mass balance. **$/lb**	$ 0.027		$ 0.020
enzyme cost (cost of production calculated in "$per lb. calcs.") divided by million FPU per year required. **$/MFPU**	**$ 4.60**		**$ 3.32**

Annual Savings Using PureVision On-Site Enzyme Production	
OVER REFERENCE MODEL:	$ 1,201,055

* .45% scale factor applied; SHCF

* * MFPU = millon FPU

Recommendations for Further Work

- Feedstock Handling
- Pretreatment
- Detoxification
- Physical Properties
- Separation of Hydrolysis and Co-fermentation
- Cellulase Production
- Use of Stillage as a Nutrient

Summary

"While not economically attractive at this time, there are numerous areas for further work. When these issues are addressed, the economics will be much more attractive."